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APPLICATION FOR PATENT

ON

MULTI-MODE SPEAKER OPERATING FROM EITHER DIGITAL OR ANALOG SOURCES

BY

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MULTI-MODE SPEAKER OPERATING FROM EITHER DIGITAL OR ANALOG SOURCES

FIELD OF THE INVENTION

[0001] The present invention generally relates to the field of audio reproducing systems, and particularly where an audio reproducing system may connect to various sources of audio content.

BACKGROUND OF THE INVENTION

[0002] Standard interfaces for information handling systems or component audio systems utilize a physical wire for transmission of audio to amplifiers and speaker systems. In the past, the signal on this wire was a simple analog audio wave with a frequency usually within the range of human hearing. Today, many information handling systems or component audio systems are capable of outputting digital audio in many forms such as Sony/Philips Digital Interface IEC958 Interface Standard (S/PDIF) or Universal Serial Bus (USB). The user must make sure that they connect the correct type of speaker or amplified speaker to the correct type of audio output. Since many users are not aware of the type of audio their system outputs and since many system manufacturers would like to reduce the number of types of speaker components that they sell, it would be highly desirable to have one speaker component that can be connected to either an analog audio source or a digital audio source and operate without the need for the user to configure the system or the speaker. This is useful for audio formats such as S/PDIF, since the output jack on the system is similar to an analog audio output jack and is therefore easy to confuse.

SUMMARY OF THE INVENTION

[0003] The present invention is directed to an amplified speaker system where the speaker system has a single input that can accommodate either a standard analog audio signal or a digital audio signal without any user action. In one embodiment, a controller detects the type of audio. If the controller does not detect a digital signal, the raw analog audio is routed to the amplifier through a multiplexer or other switching means. If the

controller detects a digital signal, the output of a digital-to-analog converter is routed to the amplifier instead. The digital-to-analog converter receives the input signal, removes headers and packet information, restores timing, converts the digital audio data into analog audio data and any other functions that are required to convert from the digital audio format into analog audio.

[0004] In another embodiment, instead of using a controller to detect a digital signal, a filter that detects a range of frequencies, detects a minimum frequency or detects a maximum frequency is used to determine if an analog signal or a digital signal is present. For example, if the filter is tuned to detect frequencies below 40 kHz, it would signal true when an analog audio signal is used and false when a digital audio signal is used. Further improvements may be made on this scheme such as filtering above 60 Hz to eliminate power-line noise and to include hysterisis so that a period of quiet does not cause the detector to erroneously change.

[0005] In another embodiment, the detector can detect more than one form of digital audio, perhaps, but not limited to USB audio and S/PDIF audio. In this embodiment, there are more than one digital-to-analog converters and the detector signals the selector to choose either the input signal if no digital audio is detected or the corresponding digital-to-analog converter if a digital audio signal is detected.

[0006] It is to be understood that both the forgoing general description and the following detailed description are exemplary only and are not restrictive of the invention as claimed. The general functions of this invention may be combined in different ways to provide the same functionality while still remaining within the scope of this invention. Parts of this invention may be housed in different cabinetry, for example, the active circuits in one cabinet and the speakers in another. Furthermore, for multiple-channel amplified speaker systems, it may be advantageous to use one common detection circuit to determine if the input signals are analog or digital instead of one for each channel. Additionally, the same controller that converts the digital signal to analog can also perform the detection function, eliminating a separate device for detecting the type of input signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The numerous advantages of the present invention may be better understood by those skilled in the art by reference to the accompanying figures in which:

[0008] FIG. 1 shows a block diagram of a dual-mode, digital/analog amplified speaker.

[0009] FIG. 2 shows a block diagram of a dual-mode, digital/analog amplified speaker using a filter to detect the presence of a digitally encoded audio signal.

[0010] FIG. 3 shows a block diagram of a multi-mode, digital/analog amplified speaker supporting multiple types of digitally encoded audio.

[0011] FIG. 4 shows a flow chart of the digital/analog amplified speaker.

DETAILED DESCRIPTION

[0012] Reference will now be made in detail to the presently discussed embodiment of the invention, an example of which is illustrated in the accompanying drawings.

[0013] Referring now to **FIG. 1**, a hardware system in accordance with the present invention is shown. The hardware system shown in **FIG. 1** shows a dual-mode digital/analog speaker system that automatically detects what type of signal it is receiving and decides if a digital-to-analog conversion is needed before presenting the signal to the speaker. The dual-mode speaker system **100** includes a speaker input **110** which can be analog or one of the many forms of digital audio, possibly S/PDIF or USB digital audio as an example. The speaker input **110** is directed to controller **120**. Controller **120** includes a digital audio detector that determines if the signal presented to the speaker input **110** is either an analog audio signal or a digital audio signal. Controller **120**

analyzes the speaker input **110** and determines if an analog audio signal is present or if a digital signal is present, providing an output that controls multiplexer **140** to select either the raw speaker input **110** if analog audio is detected or the output of a digital-to-analog converter **130** if digital audio is detected. The digital-to-analog converter **130** takes care of all functions necessary to convert the digital signal into an analog waveform, including but not limited to analyzing packet header information, decomposing packets, synchronizing the presentation of digital data and converting the digital data to analog in accordance with the digital audio standard. The output of multiplexer **140** is an analog signal that is amplified by audio amplifier **150** and presented to speaker **160**. In some designs, controller **120** may be logically combined with digital-to-analog converter **130** or other parts of the circuit. The hardware system shown in **FIG. 1** is shown as an example architecture. As an example, controller **120** may be embodied with discrete components, a microprocessor, a digital signal processor or any other circuit that can process an input signal and determine its type. Alternately, controller **120** may include a packet header detector that looks for digital information in speaker input **110** and recognizes when packet headers that conform the digital audio standard.

[0014] Referring now to **FIG. 2**, a second embodiment of the same invention is shown. In this embodiment, speaker input **210** is sent through a high-pass filter **220** to detect the presence of a digital audio source. High-pass filter **220** is an example of a digital audio detector, in that it detects whether a digital audio signal or an analog audio signal is present at speaker input **210**. If the speaker input **210** frequency is below the cut-off frequency of the high-pass filter **220**, the high-pass filter **220** will output a negligible voltage level less than reference voltage, Vref **226**. If the speaker input **210** frequency is above the cut-out frequency of the high-pass filter **220**, the high-pass filter **220** will output a voltage level greater than Vref **226**. Since analog audio frequencies are usually less than 20 kHz and digital audio carrier frequencies are usually much higher than 20 kHz, a wide range of high-pass filters **220** can be used to discriminate between an analog or digital signal at speaker input **210**.. In this circuit, when a digital audio signal is presented at speaker input **210** and the voltage greater than Vref **226** is passed from high-pass filter **220**, comparator **225** signals a level output sufficient to switch multiplexer **240** from its input connected to the speaker input **210** to its input from the output of the

digital-to-analog converter **230**. Otherwise, multiplexer **240** selects its input that comes directly from the speaker input **210**. The output of the multiplexer **240** is amplified by audio amplifier **250** and presented to speaker **260**. It should be noted that a high-pass filter was used to show one way this invention could operate and a multitude of frequency discriminating filters can be used without altering the operation of this invention. For example, a low-pass filter could be used with the inputs of the multiplexer **240** being reversed. Also, if a low-pass filter is used to detect the presence of an analog audio signal, it is anticipated that some form of hysterisis and storage may be utilized so that the multiplexer **240** does not switch to its digital inputs inadvertently during quiet passages in the audio signal.

[0015] Referring now to **FIG. 3,** a third embodiment of the present invention is shown that automatically detects a multitude of signal types it is being fed and determines which digital-to-analog conversion is needed before presenting the signal to the speaker. The multi-mode speaker system **300** includes a speaker input **310** which can be analog or one of the many forms of digital audio, possibly S/PDIF or USB digital audio as an example. The speaker input **310** is directed to controller **320**. Controller **320** is a digital audio detection means, in that it detects whether a digital audio signal or an analog audio signal is present at speaker input **310.** Controller **320** analyzes the speaker input **310** and determines if an analog audio signal is present or if a digital audio signal is present and which type of digital audio signal is present. Since, in this embodiment, there can be two or more distinct forms of digital audio acceptable by the multi-mode speaker system, controller **320** not only detects whether analog or digital audio is present, but which form of digital audio is present. Alternately, controller **320** may include a packet header detector that looks for digital information in speaker input **310** and recognizes when packet headers that conform the digital audio standard. Controller **320** provides an output that controls multiplexer **340** to select either the raw speaker input **310** if analog audio is detected or the output of the corresponding digital-to-analog converters **330** or **335** if digital audio is detected. Two digital-to-analog converters **330** and **335** are shown in **Fig. 3**, but as indicated by the series of dots, more digital-to-analog converters may be included to convert more than two forms of digital audio into analog audio. The digital-to-analog converters **330** and **335** take care of all functions necessary to convert the

digital signal into an analog waveform, including but not limited to analyzing packet header information, decomposing packets, synchronizing the presentation of digital data and converting the digital data to analog in accordance with the selected digital audio standard. As an example, one digital-to-analog converter **330** may convert from S/PDIF to analog and the other digital-to-analog converter **335** may convert from USB digital audio to analog. The output of multiplexer **340** is an analog signal that is amplified by audio amplifier **350** and presented to speaker **360**. In some designs, controller **320** may be logically combined with one or both digital-to-analog converter **330** or other parts of the circuit. The hardware system shown in **FIG. 3** is shown as an example architecture but those skilled in the art will see many variations that still achieve the same results.

[0016] Referring now to **FIG.4**, a fourth embodiment of the present invention is shown. In **FIG.4**, the range of input frequencies is determined in step **410**. In decision point **420**, the range of input frequencies is checked to determine if they are within the audio frequency spectrum. This spectrum is usually 20 Hz to 20,000 Hz, but any frequency range not used by the digital encoding method can be used. For example, the IEC958 standard for consumer digital audio (S/PDIF) uses encoding frequencies in the range of 5-6 MHz. Hence, if the decision point **420** detected frequencies above 5 MHz as being in a range greater than audio frequencies, then the decision would be "Y" if S/PDIF audio is present and "N" if analog audio is present.

If digital audio is detected ("Y"), it is decoded into analog audio **430** then amplified and presented to the speaker **450**. If analog audio is detected ("N"), the input signal which is already analog, is selected **440** and amplified and presented to the speaker **460**.

[0017] Although the invention has been described with a certain degree of particularity, it should be recognized that elements thereof may be altered by persons skilled in the art without departing from the spirit and scope of the invention. It is believed that the automatic detection and switching between analog audio and digital audio inputs of the present invention and many of its attendant advantages will be understood by the forgoing description, and it will be apparent that various changes may be made in the form, construction and arrangement of the components thereof without

departing from the scope and spirit of the invention or without sacrificing all of its material advantages, the form herein before described being merely an explanatory embodiment thereof, and further without providing substantial change thereto. It is the intention of the claims to encompass and include such changes.